

Power System Analysis

B EE478: Simulation Project #1

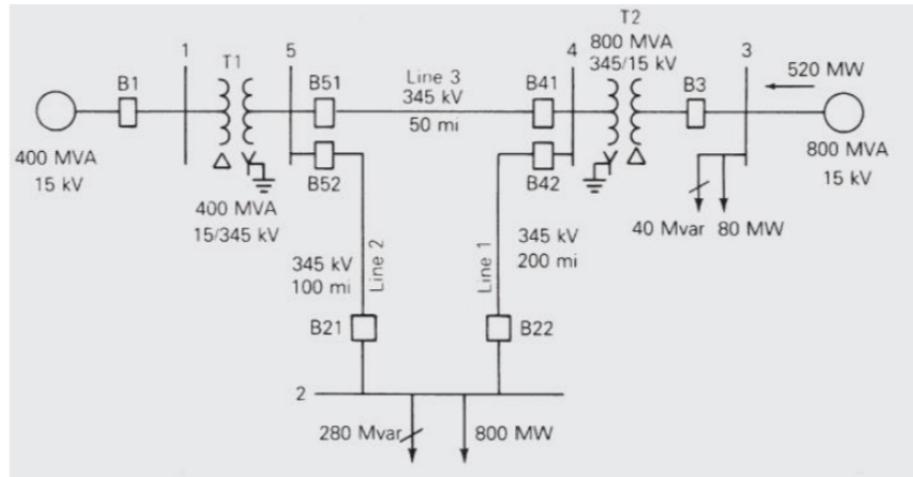
by

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Lab Due Date: 11/14/2023

1. The single-line diagram of a five-bus power system is shown below. Machine, line, and transformer data are given in the following tables. This system is initially unloaded. Prefault voltages at all buses are 1.05 per unit.

Figure 1 - Power System Circuit Schematic



Single line diagram for the five-bus power system

TABLE 7.3

Synchronous machine data for SYMMETRICAL SHORT CIRCUITS program*

Bus	Machine Subtransient Reactance— X_d'' (per unit)
1	0.045
3	0.0225

* $S_{base} = 100 \text{ MVA}$
 $V_{base} = 15 \text{ kV}$ at buses 1, 3
 $= 345 \text{ kV}$ at buses 2, 4, 5

for Positive Sequence
New per unit (P.U.)

TABLE 7.4

Line data for SYMMETRICAL SHORT CIRCUITS program

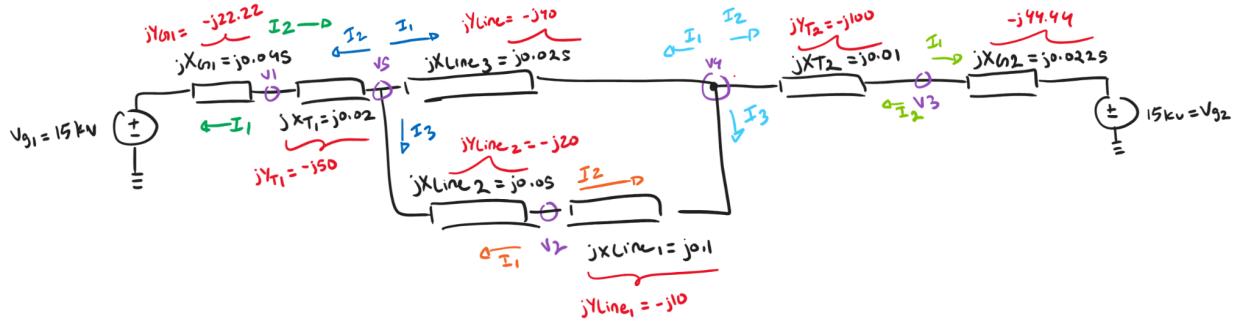
Bus-to-Bus	Equivalent Positive-Sequence Series Reactance (per unit)
2-4	0.1
2-5	0.05
4-5	0.025

TABLE 7.5

Transformer data for SYMMETRICAL SHORT CIRCUITS program

Bus-to-Bus	Leakage Reactance— X (per unit)
1-5	0.02
3-4	0.01

A) Hand calculate the bus admittance matrix Y_{bus} . Clearly show how different elements of the bus admittance matrix are calculated. (5 Points)



$$@v_1$$

$$I_1 = [V_1 - V_3](-j22.22)$$

$$I_2 = [V_1 - V_2](-j50)$$

$$0 = I_1 + I_2$$

$$0 = V_1 [-j22.22 + (-j50)] + V_3 [j50] - V_3 [(-j22.22)]$$

$$0 = V_1 [-j22.22] + V_3 [j50] - V_3 [(-j22.22)]$$

@v₂

$$I_1 = [V_2 - V_3](-j40)$$

$$I_2 = [V_2 - V_1](-j50)$$

$$I_3 = [V_2 - V_3](-j20)$$

$$0 = I_1 + I_2 + I_3$$

$$0 = -V_1 [(-j50)] - V_2 [(-j20)] - V_3 [(-j40)] + V_3 [(-j40) + (-j50) + (-j20)]$$

$$0 = -V_1 [(-j50)] - V_2 [(-j20)] - V_3 [(-j40)] + V_3 [(-j110)]$$

@v₃

$$I_1 = [V_3 - V_2](-j20)$$

$$I_2 = [V_3 - V_1](-j10)$$

$$0 = I_1 + I_2$$

$$0 = V_2 [(-j20) + (-j10)] - V_4 [(-j10)] - V_5 [(-j20)]$$

$$0 = V_2 [(-j30)] - V_4 [(-j10)] - V_5 [(-j20)]$$

$\textcircled{C} V_4$

$$I_1 = [V_4 - V_5] (-j40)$$

$$I_2 = [V_4 - V_3] (-j100)$$

$$I_3 = [V_4 - V_2] (-j10)$$

$$0 = I_1 + I_2 + I_3$$

$$0 = -V_2[(-j10)] - V_3[(-j100)] + V_4[(-j40) + (-j10) + (-j100)] - V_5[(-j40)]$$

$$0 = -V_2[(-j10)] - V_3[(-j100)] + V_4[(-j150)] - V_5[(-j40)]$$

$\textcircled{C} V_3$

$$I_1 = [V_3 - V_{92}] (-j44.44)$$

$$I_2 = [V_3 - V_4] (-j100)$$

$$0 = I_1 + I_2$$

$$0 = V_3[(-j44.44) + (-j100)] - V_4[(-j100)] - V_{92}(-j100)$$

$$0 = V_3[(-j144.44)] - V_4(-j100) - V_{92}(-j100)$$

$$\left(\begin{array}{ccccc} -j72.22 & 0 & 0 & 0 & j50 \\ 0 & -j30 & 0 & j10 & j20 \\ 0 & 0 & -j144.44 & j100 & 0 \\ 0 & j10 & j100 & -j150 & j40 \\ j50 & j20 & 0 & j40 & -j100 \end{array} \right) = 4 \text{ bus}$$

B) Use the Y_{bus} to calculate the bus impedance matrix (Z_{bus}). (5 Points)

$$Y_{bus}^{-1} = Z_{bus}$$

$$\left[\begin{array}{ccccc} -j2.22 & 0 & 0 & 0 & j50 \\ 0 & -j30 & 0 & j10 & j20 \\ 0 & 0 & -j144.44 & j100 & 0 \\ 0 & j10 & j100 & -j150 & j40 \\ j50 & j20 & 0 & j40 & -j100 \end{array} \right]^{-1} = j \left[\begin{array}{ccccc} 0.0279 & 0.0177 & 0.0085 & 0.0129 & 0.0204 \\ 0.0177 & 0.05695 & 0.0136 & 0.0197 & 0.0255 \\ 0.0085 & 0.0136 & 0.0182 & 0.0163 & 0.0122 \\ 0.01229 & 0.0197 & 0.0163 & 0.0236 & 0.0177 \\ 0.0204 & 0.0255 & 0.0122 & 0.01774 & 0.0294 \end{array} \right] = Z_{bus}$$

$Y_{bus}^{-1} \rightarrow Z_{bus}$

C) Use the appropriate elements of the Z_{bus} to calculate the fault current for three-phase faults at each of the buses. (10 Points)

$\mathcal{C} I_{Fault} @ V_1$

$$I_{Fault} = \frac{V_{Prefault}}{Z_{th@V_1}} = \frac{1.05}{j0.0279} = -j37.63 \text{ P.U.}$$

$\mathcal{C} I_{Fault} @ V_2$

$$I_{Fault} = \frac{V_{Prefault}}{Z_{th@V_2}} = \frac{1.05}{j0.05695} = -j18.43 \text{ P.U.}$$

$\mathcal{C} I_{Fault} @ V_3$

$$I_{Fault} = \frac{V_{Prefault}}{Z_{th@V_3}} = \frac{1.05}{j0.0182} = -j57.69 \text{ P.U.}$$

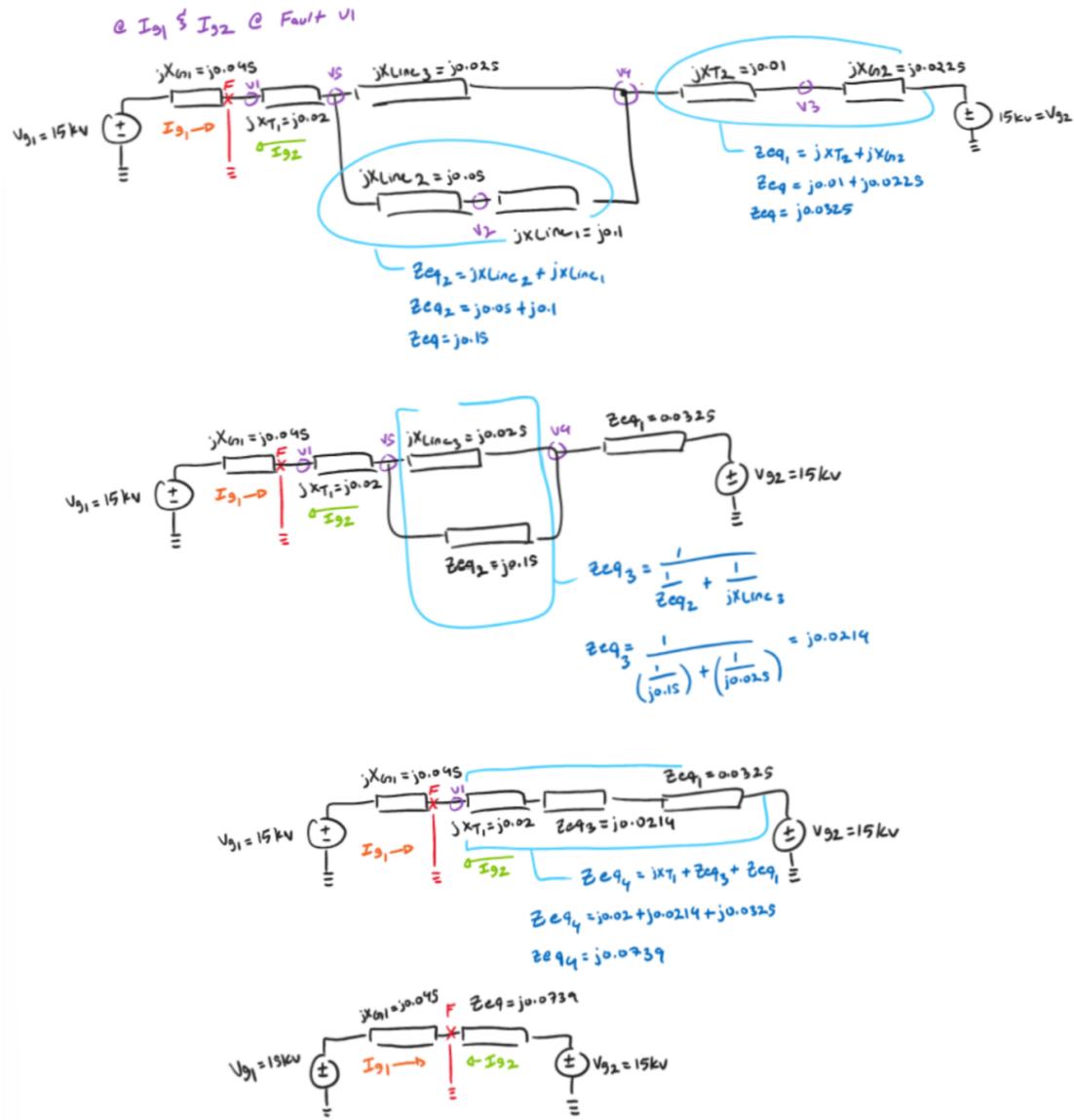
$\mathcal{C} I_{Fault} @ V_4$

$$I_{Fault} = \frac{V_{Prefault}}{Z_{th@V_4}} = \frac{1.05}{j0.0236} = -j44.49 \text{ P.U.}$$

$\mathcal{C} I_{Fault} @ V_5$

$$I_{Fault} = \frac{V_{Prefault}}{Z_{th@V_5}} = \frac{1.05}{j0.0294} = -j35.71 \text{ P.U.}$$

D) Use the current-division rule to calculate the generators' contributions to the fault current ($I_{G1}(F)$, $I_{G2}(F)$) for each fault (Convert the Δ -connected lines to its equivalent Y , if necessary). (20 Points)

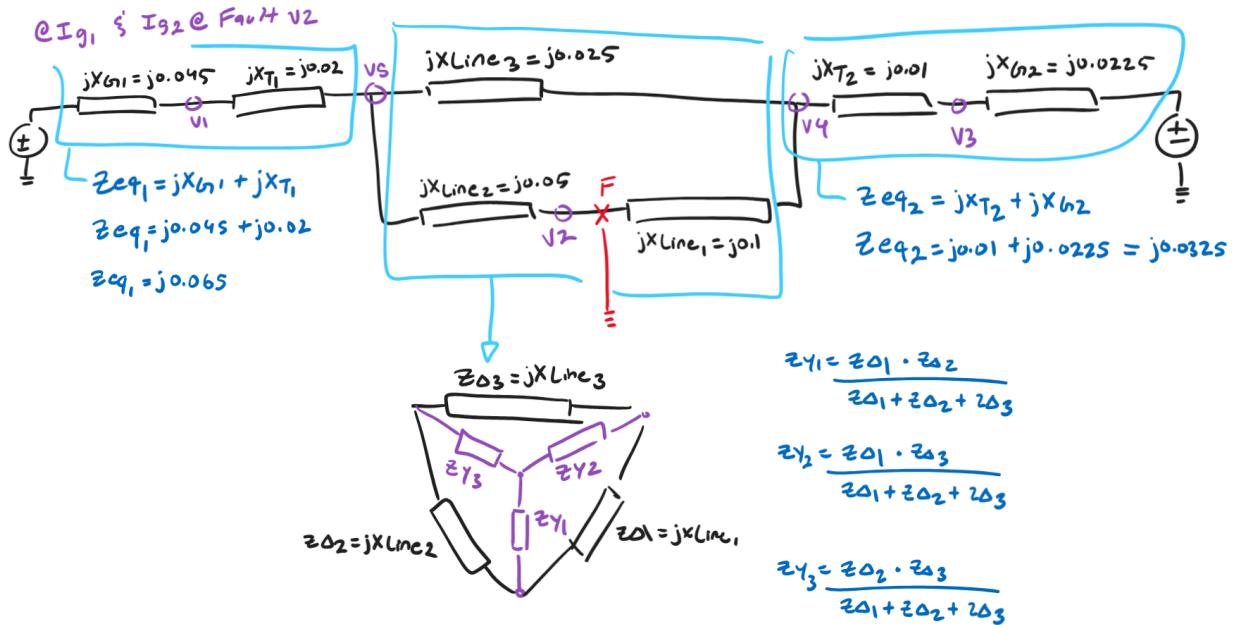


$$\text{C } I_{g1} = \left[\frac{P_T}{P_X + P_T} \right] I_T \quad \begin{cases} \text{Current divisor} \\ \text{Circuit } V_1 \end{cases}$$

$$I_{g1} = \left[\frac{Z_{eq}}{jX_{G1} + Z_{eq}} \right] I_F = \left[\frac{j0.0739}{j0.045 + j0.0739} \right] (-j37.63) = -j23.57 \text{ p.u.}$$

$$\text{C } I_{g2}$$

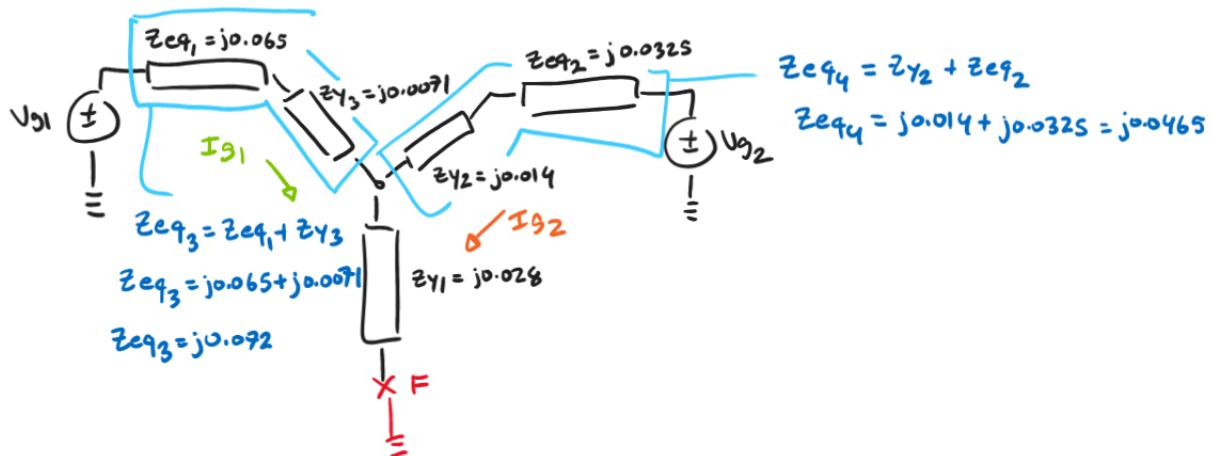
$$I_{g2} = \left[\frac{jX_{G1}}{Z_{eq} + jX_{G1}} \right] (I_F) = \left[\frac{j0.045}{j0.0739 + j0.045} \right] (-j37.63) = -j14.24 \text{ p.u.}$$

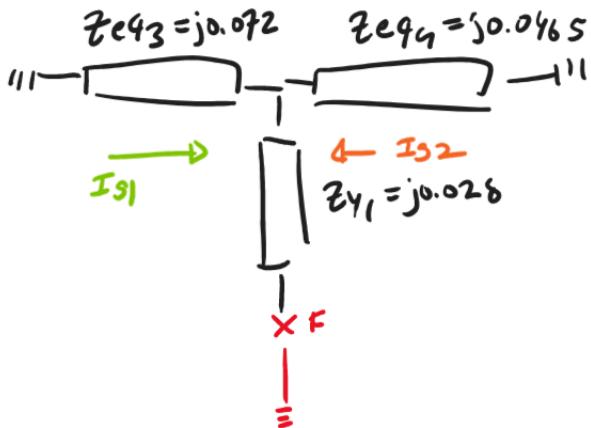


$$zY_1 = \frac{jX_{L_1} \cdot jX_{L_2}}{jX_{L_1} + jX_{L_2} + jX_{L_3}} = \frac{j0.01 \cdot j0.05}{j0.01 + j0.05 + j0.025} = j0.028$$

$$zY_2 = \frac{jX_{L_1} + jX_{L_3}}{jX_{L_1} + jX_{L_2} + jX_{L_3}} = \frac{j0.01 + j0.025}{j0.01 + j0.05 + j0.025} = j0.014$$

$$zY_3 = \frac{jX_{L_2} + jX_{L_3}}{jX_{L_1} + jX_{L_2} + jX_{L_3}} = \frac{j0.05 + j0.025}{j0.01 + j0.05 + j0.025} = j0.0071$$



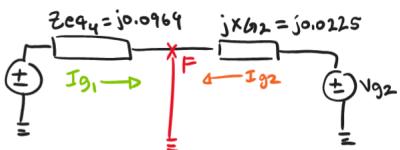
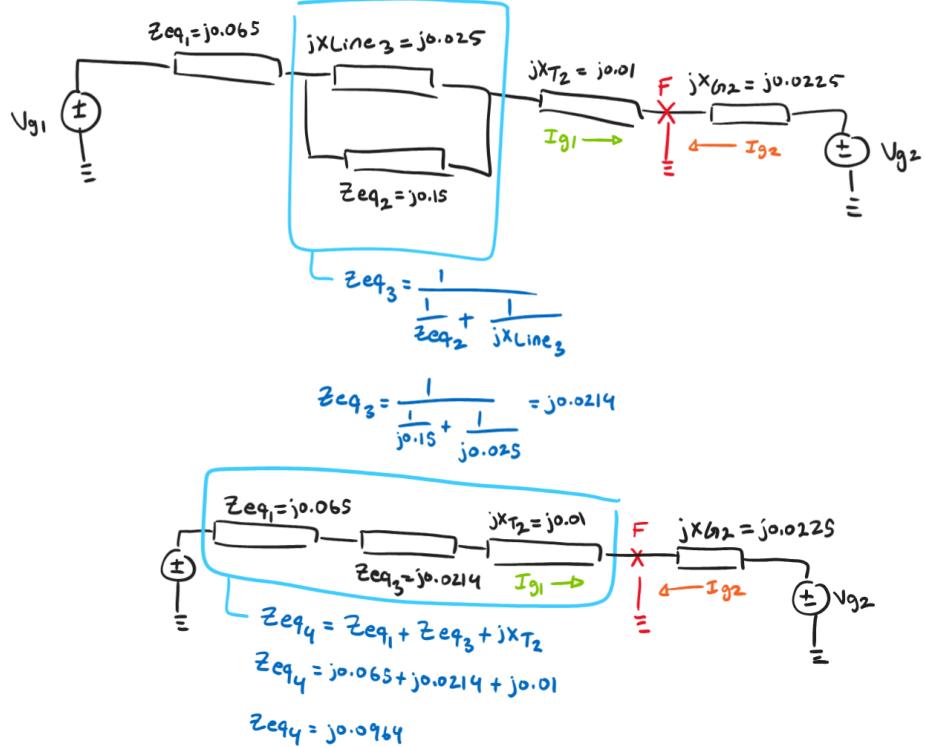
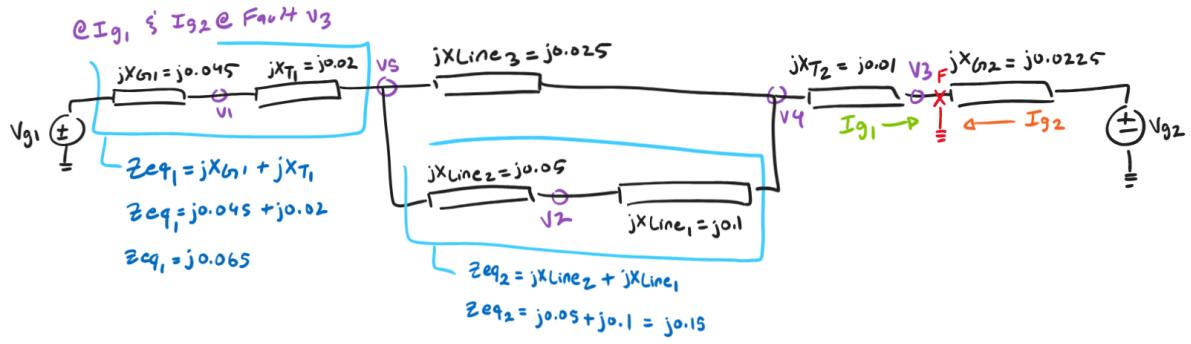


@ I_{g1}

$$I_{g1} = \left[\frac{z_{eq4}}{z_{eq3} + z_{eq4}} \right] (I_F) = \frac{j0.0465}{j0.072 + j0.0465} (-j18.43) = -j4.23 \text{ p.u.}$$

@ I_{g2}

$$I_{g2} = \left[\frac{z_{eq3}}{z_{eq3} + z_{eq4}} \right] (I_F) = \frac{j0.072}{j0.072 + j0.0465} (-j18.43) = -j11.19 \text{ p.u.}$$

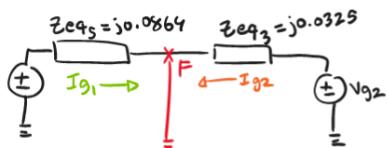
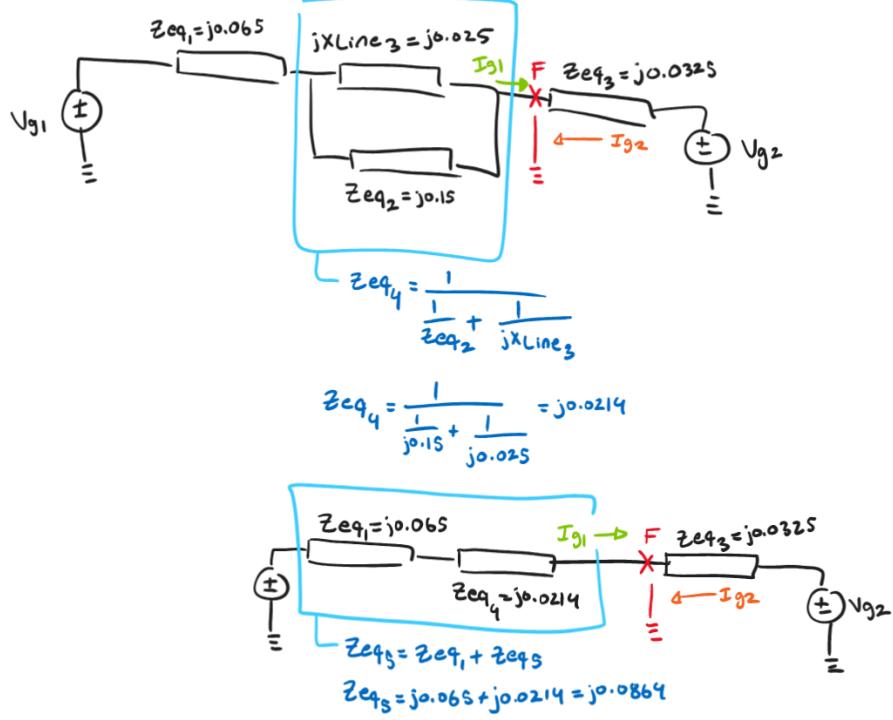
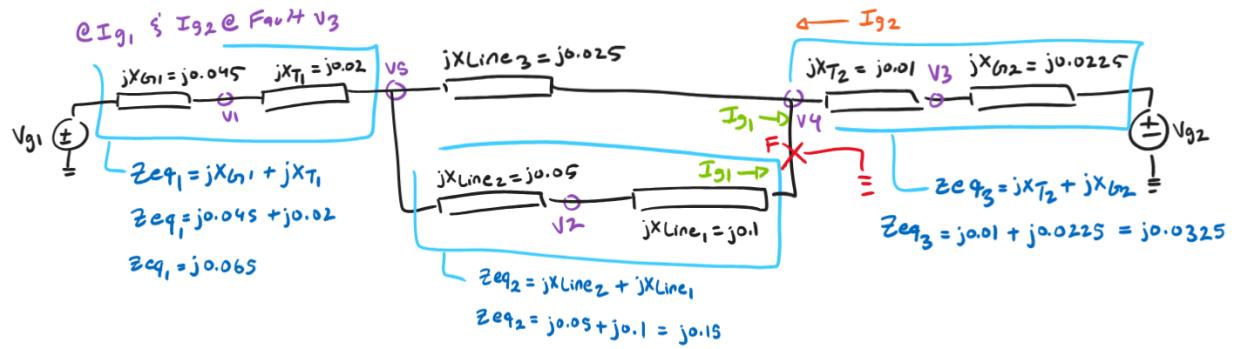


$\text{C} I_{g1}$

$$I_{g1} = \left[\frac{Z_{eq_4}}{Z_{eq_4} + jXG_2} \right] (I_F) = \left[\frac{j0.0964}{(j0.0964) + (j0.0225)} \right] (-j57.69) = -j46.77 \text{ p.u.}$$

$\text{C} I_{g2}$

$$I_{g2} = \left[\frac{jXG_2}{Z_{eq_4} + jXG_2} \right] (I_F) = \left[\frac{(j0.0225)}{(j0.0964) + (j0.0225)} \right] (-j57.69) = -j10.91 \text{ p.u.}$$

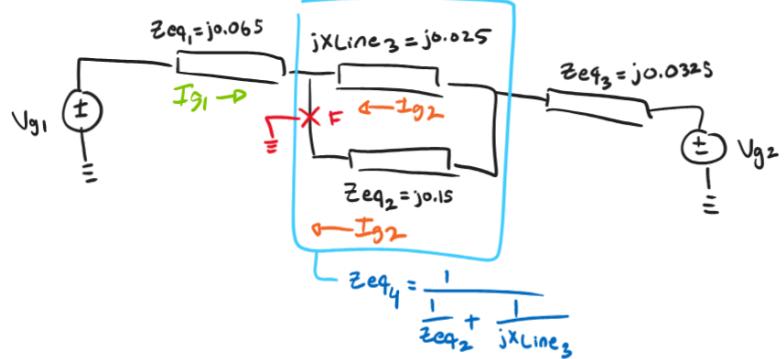
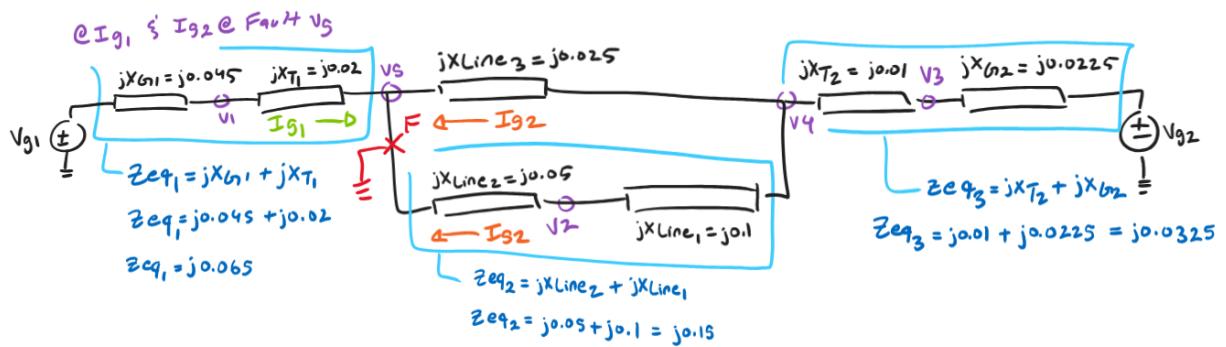


$\text{At } I_{g1}$

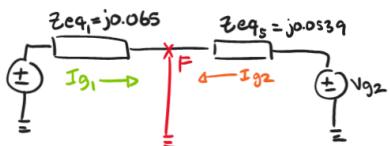
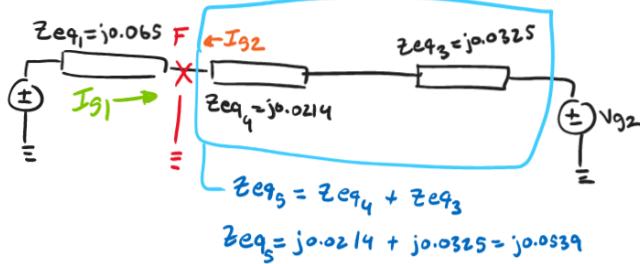
$$I_{g1} = \left[\frac{Z_{eq_5}}{Z_{eq_5} + Z_{eq_3}} \right] (I_F) = \left[\frac{(j0.0864)}{(j0.0864) + (j0.0325)} \right] (-j44.49) = -j32.33 \text{ P.U.}$$

$\text{At } I_{g2}$

$$I_{g2} = \left[\frac{Z_{eq_3}}{Z_{eq_5} + Z_{eq_3}} \right] (I_F) = \left[\frac{(j0.0325)}{(j0.0864) + (j0.0325)} \right] (-j44.49) = -j12.16 \text{ P.U.}$$



$$Z_{eq_4} = \frac{1}{\frac{1}{j0.15} + \frac{1}{j0.025}} = j0.0214$$



$\text{C } I_{g1}$

$$I_{g1} = \begin{bmatrix} Z_{eq_5} \\ Z_{eq_5} + Z_{eq_1} \end{bmatrix}, \quad (I_F) = \begin{bmatrix} (j0.0539) \\ ((j0.0539) + (j0.065)) \end{bmatrix} (-j35.71) = -j16.18 \text{ p.u.}$$

$\text{C } I_{g2}$

$$I_{g2} = \begin{bmatrix} Z_{eq_1} \\ Z_{eq_5} + Z_{eq_1} \end{bmatrix} (I_F) = \begin{bmatrix} (j0.065) \\ ((j0.0539) + (j0.065)) \end{bmatrix} (-j35.71) = -j19.52 \text{ p.u.}$$

E) Use the Z_{bus} and the vector of bus injected currents to calculate the per-unit bus voltages during each fault ($V_1 (F), V_2 (F), V_3 (F), V_4 (F), V_5 (F)$). (20 Points)

$\text{C } V_{\text{Fault}} \text{ C } V_1$

$$j \begin{bmatrix} 0.0279 & 0.0197 & 0.0085 & 0.0129 & 0.0204 \\ 0.0177 & 0.05695 & 0.0196 & 0.0197 & 0.0255 \\ 0.0085 & 0.0136 & 0.0182 & 0.0163 & 0.0122 \\ 0.01229 & 0.0197 & 0.0163 & 0.0236 & 0.0177 \\ 0.0204 & 0.0255 & 0.0122 & 0.01774 & 0.0294 \end{bmatrix} \cdot \begin{bmatrix} -(-j37.63) \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix} = \begin{bmatrix} V_1(z) = -1.05 \\ V_2(z) = -0.66 \\ V_3(z) = -0.32 \\ V_4(z) = -0.46 \\ V_5(z) = -0.76 \end{bmatrix} \text{ P.U.}$$

Z_{bus} I_{bus}

Voltage @ System #2

- If here due to Fault location

$$\begin{bmatrix} V_1^{(1)} = 1.05 \\ V_2^{(1)} = 1.05 \\ V_3^{(1)} = 1.05 \\ V_4^{(1)} = 1.05 \\ V_5^{(1)} = 1.05 \end{bmatrix} + \begin{bmatrix} V_1(z) = -1.05 \\ V_2(z) = -0.66 \\ V_3(z) = -0.32 \\ V_4(z) = -0.46 \\ V_5(z) = -0.76 \end{bmatrix} = \begin{bmatrix} V_1(F) = 0 \\ V_2(F) = 0.39 \\ V_3(F) = 0.73 \\ V_4(F) = 0.59 \\ V_5(F) = 0.29 \end{bmatrix} \text{ P.U.}$$

Prefault voltage Voltage @ 2nd system Fault voltage

$\text{C } V_{\text{Fault}} \text{ C } V_2$

$$j \begin{bmatrix} 0.0279 & 0.0197 & 0.0085 & 0.0129 & 0.0204 \\ 0.0177 & 0.05695 & 0.0196 & 0.0197 & 0.0255 \\ 0.0085 & 0.0136 & 0.0182 & 0.0163 & 0.0122 \\ 0.01229 & 0.0197 & 0.0163 & 0.0236 & 0.0177 \\ 0.0204 & 0.0255 & 0.0122 & 0.01774 & 0.0294 \end{bmatrix} \cdot \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix} = \begin{bmatrix} V_1(z) = -0.326 \\ V_2(z) = -1.049 \\ V_3(z) = -0.251 \\ V_4(z) = -0.363 \\ V_5(z) = -0.471 \end{bmatrix} \text{ P.U.}$$

Z_{bus} I_{bus}

Voltage @ System #2

$$\begin{bmatrix} V_1^{(1)} = 1.05 \\ V_2^{(1)} = 1.05 \\ V_3^{(1)} = 1.05 \\ V_4^{(1)} = 1.05 \\ V_5^{(1)} = 1.05 \end{bmatrix} + \begin{bmatrix} V_1(z) = -0.326 \\ V_2(z) = -1.049 \\ V_3(z) = -0.251 \\ V_4(z) = -0.363 \\ V_5(z) = -0.471 \end{bmatrix} = \begin{bmatrix} V_1(F) = 0.724 \\ V_2(F) = 0.201 \\ V_3(F) = 0.799 \\ V_4(F) = 0.687 \\ V_5(F) = 0.579 \end{bmatrix} \text{ P.U.}$$

Prefault voltage Voltage @ 2nd system Fault voltage

$\text{@ } V_{\text{Fault}} @ V_3$

$$j \begin{bmatrix} 0.0279 & 0.0197 & 0.0085 & 0.0129 & 0.0204 \\ 0.0177 & 0.05695 & 0.0136 & 0.0197 & 0.0255 \\ 0.0085 & 0.0136 & 0.0182 & 0.0163 & 0.0122 \\ 0.01229 & 0.0197 & 0.0163 & 0.0236 & 0.0177 \\ 0.0204 & 0.0255 & 0.0122 & 0.01774 & 0.0294 \end{bmatrix} \cdot \begin{bmatrix} 0 \\ 0 \\ -(-j57.61) \\ 0 \\ 0 \end{bmatrix} = \begin{bmatrix} V_1(z) = -0.49 \\ V_2(z) = -0.78 \\ V_3(z) = -1.05 \\ V_4(z) = -0.94 \\ V_5(z) = -0.71 \end{bmatrix} \text{ P.U.}$$

Z_{bus} I_{bus}

Voltage @ System #2

$$\begin{bmatrix} V_1^{(1)} = 1.05 \\ V_2^{(1)} = 1.05 \\ V_3^{(1)} = 1.05 \\ V_4^{(1)} = 1.05 \\ V_5^{(1)} = 1.05 \end{bmatrix} + \begin{bmatrix} V_1(z) = -0.49 \\ V_2(z) = -0.78 \\ V_3(z) = -1.05 \\ V_4(z) = -0.94 \\ V_5(z) = -0.71 \end{bmatrix} = \begin{bmatrix} V_1(F) = 0.55 \\ V_2(F) = 0.26 \\ V_3(F) = 0.00 \\ V_4(F) = 0.10 \\ V_5(F) = 0.34 \end{bmatrix} \text{ P.U.}$$

Prefault voltage Voltage @ 2nd system Fault voltage

$\text{@ } V_{\text{Fault}} @ V_4$

$$j \begin{bmatrix} 0.0279 & 0.0197 & 0.0085 & 0.0129 & 0.0204 \\ 0.0177 & 0.05695 & 0.0136 & 0.0197 & 0.0255 \\ 0.0085 & 0.0136 & 0.0182 & 0.0163 & 0.0122 \\ 0.01229 & 0.0197 & 0.0163 & 0.0236 & 0.0177 \\ 0.0204 & 0.0255 & 0.0122 & 0.01774 & 0.0294 \end{bmatrix} \cdot \begin{bmatrix} 0 \\ 0 \\ 0 \\ -(-j44.49) \\ 0 \end{bmatrix} = \begin{bmatrix} V_1(z) = -0.947 \\ V_2(z) = -0.877 \\ V_3(z) = -0.727 \\ V_4(z) = -1.051 \\ V_5(z) = -0.790 \end{bmatrix} \text{ P.U.}$$

Z_{bus} I_{bus}

Voltage @ System #2

$$\begin{bmatrix} V_1^{(1)} = 1.05 \\ V_2^{(1)} = 1.05 \\ V_3^{(1)} = 1.05 \\ V_4^{(1)} = 1.05 \\ V_5^{(1)} = 1.05 \end{bmatrix} + \begin{bmatrix} V_1(z) = -0.947 \\ V_2(z) = -0.877 \\ V_3(z) = -0.727 \\ V_4(z) = -1.051 \\ V_5(z) = -0.790 \end{bmatrix} = \begin{bmatrix} V_1(F) = 0.503 \\ V_2(F) = 0.173 \\ V_3(F) = 0.323 \\ V_4(F) = 0.00 \\ V_5(F) = 0.26 \end{bmatrix} \text{ P.U.}$$

Prefault voltage Voltage @ 2nd system Fault voltage

$\text{@ } V_{\text{Fault}} \text{ @ } V_5$

$$j \begin{bmatrix} 0.0279 & 0.0177 & 0.0085 & 0.0129 & 0.0209 \\ 0.0177 & 0.05695 & 0.0136 & 0.0197 & 0.0255 \\ 0.0085 & 0.0136 & 0.0182 & 0.0163 & 0.0122 \\ 0.01229 & 0.0197 & 0.0163 & 0.0236 & 0.0177 \\ 0.0204 & 0.0255 & 0.0122 & 0.0174 & 0.0294 \end{bmatrix} \cdot \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ -(-j35.71) \end{bmatrix} = \begin{bmatrix} V_1^{(2)} = -0.92 \\ V_2^{(2)} = -0.91 \\ V_3^{(2)} = -0.43 \\ V_4^{(2)} = -0.63 \\ V_5^{(2)} = -1.049 \end{bmatrix}$$

Z_{bus} I_{bus}

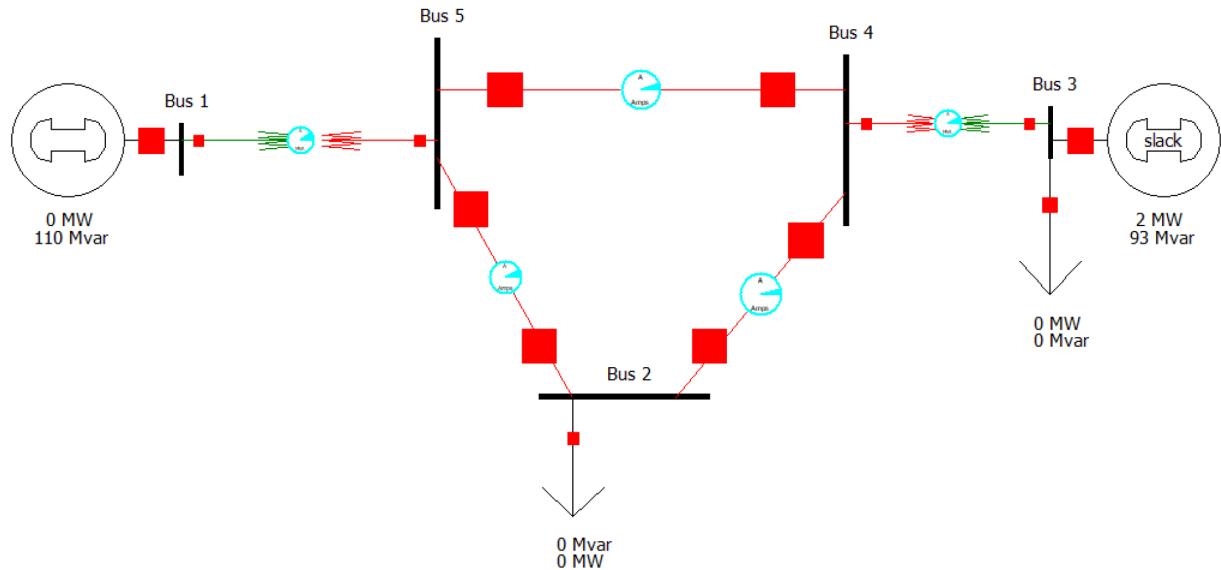
$$\begin{bmatrix} V_1^{(1)} = 1.05 \\ V_2^{(1)} = 1.05 \\ V_3^{(1)} = 1.05 \\ V_4^{(1)} = 1.05 \\ V_5^{(1)} = 1.05 \end{bmatrix} + \begin{bmatrix} V_1^{(2)} = -0.92 \\ V_2^{(2)} = -0.91 \\ V_3^{(2)} = -0.43 \\ V_4^{(2)} = -0.63 \\ V_5^{(2)} = -1.049 \end{bmatrix} = \begin{bmatrix} V_1^{(F)} = 0.321 \\ V_2^{(F)} = 0.139 \\ V_3^{(F)} = 0.611 \\ V_4^{(F)} = 0.417 \\ V_5^{(F)} = 0.00 \end{bmatrix}$$

+ = $V_{\text{Voltage @ system #2}}$

Prefault Voltage $\text{Voltage @ 2nd system}$ Fault Voltage

F) Build the five-bus power system in PowerWorld Simulator. (10 Points)

Figure 2 - PowerWorld Circuit of Figure 1

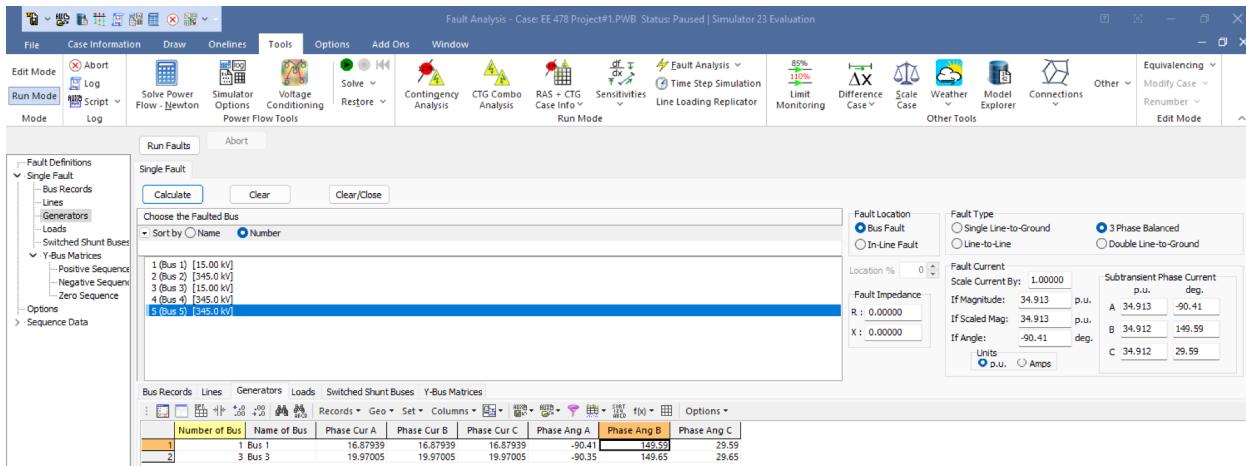


When working with the Powerworld simulation, the first thing that needs to be added are the buses, located by selecting *Draw > Network > Bus*. In the *Bus Option*, the Nominal Voltage is set to the Vbase provided by Figure 1, and the orientation seen in *Bus option > display*.

The Generator, Transmission Line, and Transformer can be located in *Draw > Network*. When adding the transmission Line and transformer, click on one of the buses and then double-right-click on a bus where you want to end. Then input your desired values which can be seen in the appendix for each component. One thing observed is that when the circuit is simulated the set parameters will change.

G) Use the power system that you built in PowerWorld Simulator for part (f) and confirm the results of parts c, d and e. Take screenshots of the dialog boxes and paste them here. (30 Points)

When the circuit, seen in Figure 2, has been constructed select run mode > Tool > the green arrow to simulate the circuit. Select Fault analysis, seen under tools, to find the results.



When a bus is selected and calculated the fault current can be located on the right side. After calculation, the generators' contributions to the fault current can be located under the Generators Tab. The per-unit bus voltages during each fault can be located under the Bus Records Tab.

G.C) The fault current for three-phase faults at each of the buses

Figure 3 - PowerWorld fault current for three-phase faults at bus 1

Fault Type	
<input type="radio"/>	Single Line-to-Ground
<input checked="" type="radio"/>	3 Phase Balanced
<input type="radio"/>	Line-to-Line
Fault Current	
Scale Current By:	1.00000
If Magnitude:	37.536 p.u.
If Scaled Mag:	37.536 p.u.
If Angle:	-90.41 deg.
Units	<input checked="" type="radio"/> p.u. <input type="radio"/> Amps
Subtransient Phase Current	
	p.u. deg.
A	37.536 -90.41
B	37.535 149.59
C	37.535 29.59

Figure 4 - PowerWorld fault current for three-phase faults at bus 2

Fault Type	
<input type="radio"/> Single Line-to-Ground	<input checked="" type="radio"/> 3 Phase Balanced
<input type="radio"/> Line-to-Line	<input type="radio"/> Double Line-to-Ground
Fault Current	
Scale Current By:	1.00000
If Magnitude:	17.576 p.u.
If Scaled Mag:	17.576 p.u.
If Angle:	-88.45 deg.
Units	<input checked="" type="radio"/> p.u. <input type="radio"/> Amps
Subtransient Phase Current	
	p.u. deg.
A	17.576 -88.45
B	17.576 151.55
C	17.576 31.55

Figure 5 - PowerWorld fault current for three-phase faults at bus 3

Fault Type	
<input type="radio"/> Single Line-to-Ground	<input checked="" type="radio"/> 3 Phase Balanced
<input type="radio"/> Line-to-Line	<input type="radio"/> Double Line-to-Ground
Fault Current	
Scale Current By:	1.00000
If Magnitude:	57.556 p.u.
If Scaled Mag:	57.556 p.u.
If Angle:	-90.00 deg.
Units	<input checked="" type="radio"/> p.u. <input type="radio"/> Amps
Subtransient Phase Current	
	p.u. deg.
A	57.556 -90.00
B	57.554 150.00
C	57.554 30.00

Figure 6 - PowerWorld fault current for three-phase faults at bus 4

Fault Current		Subtransient Phase Current	
Scale Current By: 1.00000		p.u.	deg.
If Magnitude:	44.080	p.u.	A 44.080 -90.01
If Scaled Mag:	44.080	p.u.	B 44.079 149.99
If Angle:	-90.01	deg.	C 44.079 29.99
Units	<input checked="" type="radio"/> p.u. <input type="radio"/> Amps		

Figure 7 - PowerWorld fault current for three-phase faults at bus 5

Fault Location	Fault Type	Subtransient Phase Current	
<input checked="" type="radio"/> Bus Fault <input type="radio"/> In-Line Fault	<input type="radio"/> Single Line-to-Ground <input type="radio"/> Line-to-Line <input checked="" type="radio"/> 3 Phase Balanced <input type="radio"/> Double Line-to-Ground	p.u.	deg.
Location % 0	Fault Current		
	Scale Current By: 1.00000		
Fault Impedance	If Magnitude: 34.913	p.u.	A 34.913 -90.41
R : 0.00000	If Scaled Mag: 34.913	p.u.	B 34.912 149.59
X : 0.00000	If Angle: -90.41	deg.	C 34.912 29.59
	Units	<input checked="" type="radio"/> p.u. <input type="radio"/> Amps	

G.D) The generators' contributions to the fault current ($IG1(F), IG2(F)$) for each fault

Figure 8 - PowerWorld generators' contributions to the fault current for three-phase faults at bus 1

	Number of Bus	Name of Bus	Phase Cur A	Phase Cur B	Phase Cur C	Phase Ang A	Phase Ang B	Phase Ang C
1	1 Bus 1		24.38134	24.38134	24.38134	-90.41	149.59	29.59
2	3 Bus 3		15.09142	15.09142	15.09142	-90.33	149.67	29.67

Figure 9 - PowerWorld generators' contributions to the fault current for three-phase faults at bus 2

	Number of Bus	Name of Bus	Phase Cur A	Phase Cur B	Phase Cur C	Phase Ang A	Phase Ang B	Phase Ang C
1	1 Bus 1		7.96194	7.96194	7.96194	-88.71	151.29	31.29
2	3 Bus 3		11.55071	11.55071	11.55071	-88.50	151.50	31.50

Figure 10 - PowerWorld generators' contributions to the fault current for three-phase faults at bus 3

	Number of Bus	Name of Bus	Phase Cur A	Phase Cur B	Phase Cur C	Phase Ang A	Phase Ang B	Phase Ang C
1	1 Bus 1		11.93687	11.93687	11.93687	-90.04	149.96	29.96
2	3 Bus 3		47.55530	47.55530	47.55530	-89.98	150.02	30.02

Figure 11 - PowerWorld generators' contributions to the fault current for three-phase faults at bus 4

	Number of Bus	Name of Bus	Phase Cur A	Phase Cur B	Phase Cur C	Phase Ang A	Phase Ang B	Phase Ang C
1	1 Bus 1		13.09393	13.09393	13.09393	-90.04	149.96	29.96
2	3 Bus 3		32.92290	32.92290	32.92290	-89.98	150.02	30.02

Figure 12 - PowerWorld generators' contributions to the fault current for three-phase faults at bus 5

Bus Records Lines Generators Loads Switched Shunt Buses Y-Bus Matrices								
	Number of Bus	Name of Bus	Phase Cur A	Phase Cur B	Phase Cur C	Phase Ang A	Phase Ang B	Phase Ang C
1	1	Bus 1	16.87939	16.87939	16.87939	-90.41	149.59	29.59
2	3	Bus 3	19.97005	19.97005	19.97005	-90.35	149.65	29.65

G.E) The per-unit bus voltages during each fault ($V_1(F), V_2(F), V_3(F), V_4(F), V_5(F)$)

Figure 13 - PowerWorld bus voltages during each fault for three-phase faults at bus 1

Bus Records Lines Generators Loads Switched Shunt Buses Y-Bus Matrices								
	Number	Name	Phase Volt A	Phase Volt B	Phase Volt C	Phase Ang A	Phase Ang B	Phase Ang C
1	1	Bus 1	0.00000	0.00000	0.00000	0.36	-119.64	120.36
2	2	Bus 2	0.33767	0.33767	0.33767	5.39	-114.61	125.39
3	3	Bus 3	0.73045	0.73045	0.73045	0.18	-119.82	120.18
4	4	Bus 4	0.57954	0.57954	0.57954	0.31	-119.69	120.31
5	5	Bus 5	0.26310	0.26310	0.26310	-0.41	-120.41	119.59

Figure 14 - PowerWorld bus voltages during each fault for three-phase faults at bus 2

Bus Records Lines Generators Loads Switched Shunt Buses Y-Bus Matrices								
	Number	Name	Phase Volt A	Phase Volt B	Phase Volt C	Phase Ang A	Phase Ang B	Phase Ang C
1	1	Bus 1	0.73911	0.73911	0.73911	-1.23	-121.23	118.77
2	2	Bus 2	0.00000	0.00000	0.00000	-174.60	65.40	-54.60
3	3	Bus 3	0.81022	0.81022	0.81022	-0.46	-120.46	119.54
4	4	Bus 4	0.69479	0.69479	0.69479	-0.78	-120.78	119.22
5	5	Bus 5	0.58006	0.58006	0.58006	-1.92	-121.92	118.08

Figure 15 - PowerWorld bus voltages during each fault for three-phase faults at bus 3

Bus Records Lines Generators Loads Switched Shunt Buses Y-Bus Matrices								
	Number	Name	Phase Volt A	Phase Volt B	Phase Volt C	Phase Ang A	Phase Ang B	Phase Ang C
1	1	Bus 1	0.56002	0.56002	0.56002	-0.76	-120.76	119.24
2	2	Bus 2	0.21678	0.21678	0.21678	7.16	-112.84	127.16
3	3	Bus 3	0.00000	0.00000	0.00000	0.00	-116.57	116.57
4	4	Bus 4	0.10000	0.10000	0.10000	-0.09	-120.09	119.91
5	5	Bus 5	0.32132	0.32132	0.32132	-1.30	-121.30	118.70

Figure 16 - PowerWorld bus voltages during each fault for three-phase faults at bus 4

Bus Records Lines Generators Loads Switched Shunt Buses Y-Bus Matrices								
	Number	Name	Phase Volt A	Phase Volt B	Phase Volt C	Phase Ang A	Phase Ang B	Phase Ang C
1	1	Bus 1	0.50796	0.50796	0.50796	-0.83	-120.83	119.17
2	2	Bus 2	0.13439	0.13439	0.13439	11.64	-108.36	131.64
3	3	Bus 3	0.32923	0.32923	0.32923	0.02	-119.98	120.02
4	4	Bus 4	0.00000	0.00000	0.00000	-0.01	-120.01	119.99
5	5	Bus 5	0.24613	0.24613	0.24613	-1.67	-121.67	118.33

Figure 17 - PowerWorld bus voltages during each fault for three-phase faults at bus 5

Bus Records Lines Generators Loads Switched Shunt Buses Y-Bus Matrices								
	Number	Name	Phase Volt A	Phase Volt B	Phase Volt C	Phase Ang A	Phase Ang B	Phase Ang C
1	1	Bus 1	0.33759	0.33759	0.33759	-0.41	-120.41	119.59
2	2	Bus 2	0.11296	0.11296	0.11296	17.17	-102.83	137.17
3	3	Bus 3	0.62068	0.62068	0.62068	0.28	-119.72	120.28
4	4	Bus 4	0.42100	0.42100	0.42100	0.58	-119.42	120.58
5	5	Bus 5	0.00000	0.00000	0.00000	179.72	59.72	-60.28

Appendix:

Appendix 1 - Final Answer:

TABLE 7.6
 Z_{bus} for Example 7.5

$$j \begin{bmatrix} 0.0279725 & 0.0177025 & 0.0085125 & 0.0122975 & 0.020405 \\ 0.0177025 & 0.0569525 & 0.0136475 & 0.019715 & 0.02557 \\ 0.0085125 & 0.0136475 & 0.0182425 & 0.016353 & 0.012298 \\ 0.0122975 & 0.019715 & 0.016353 & 0.0236 & 0.017763 \\ 0.020405 & 0.02557 & 0.012298 & 0.017763 & 0.029475 \end{bmatrix}$$

TABLE 7.7

Fault currents and bus voltages for Example 7.5

Fault Bus	Fault Current (per unit)	Contributions to Fault Current		
		Gen Line or TRSF	Bus-to-Bus	Current (per unit)
1	37.536	G 1	GRND-1	23.332
		T 1	5-1	14.204
2	18.436	L 1	4-2	6.864
		L 2	5-2	11.572
3	57.556	G 2	GRND-3	46.668
		T 2	4-3	10.888
4	44.456	L 1	2-4	1.736
		L 3	5-4	10.412
5	35.624	T 2	3-4	32.308
		L 2	2-5	2.78
		L 3	4-5	16.688
		T 1	1-5	16.152

$V_F = 1.05$ Fault Bus:	Per-Unit Bus Voltage Magnitudes during the Fault				
	Bus 1	Bus 2	Bus 3	Bus 4	Bus 5
1	0.0000	0.7236	0.5600	0.5033	0.3231
2	0.3855	0.0000	0.2644	0.1736	0.1391
3	0.7304	0.7984	0.0000	0.3231	0.6119
4	0.5884	0.6865	0.1089	0.0000	0.4172
5	0.2840	0.5786	0.3422	0.2603	0.0000

Link for Reference on how to use PowerWorld Simulation:

<https://www.youtube.com/watch?v=g46LVp-jWPQ>

<https://www.youtube.com/watch?v=2Gy6vT9fDk0>

Generator #2 Parameters:

Appendix 2 - Generator 2 Display Info Set Parameters (Rigth Generator)

Generator Options

Bus Number	3	<input type="button" value="Find By Number"/>	Status	<input type="radio"/> Open	<input checked="" type="radio"/> Closed	Generator MVA Base	100.00
Bus Name	Bus 3	<input type="button" value="Find By Name"/>	Fuel Type	UN (Unknown) [PW=0] [EPC=0]			
ID	1	<input type="button" value="Find ..."/>	Unit Type				
Area Name	1						
Labels ...	no labels						

Display Information Power and Voltage Control Costs Fault Parameters Owners, Area, etc Custom Stability

Display Size Orientation Right Rotor Shape Dog Bone
 Scale Width with Size Up Fill Rotor Symbol with Color 2
 Left Fill with Color 2
 Down
Display Width
Pixel Thickness
 Anchored Link To New Generator

Appendix 3 - Generator 2 Fault Parameters Set Parameters (Rigth Generator)

Generator Options

Bus Number	3	<input type="button" value="Find By Number"/>	Status	<input type="radio"/> Open	<input checked="" type="radio"/> Closed	Generator MVA Base	100.00
Bus Name	Bus 3	<input type="button" value="Find By Name"/>	Fuel Type	UN (Unknown) [PW=0] [EPC=0]			
ID	1	<input type="button" value="Find ..."/>	Unit Type				
Area Name	1						
Labels ...	no labels						

Display Information Power and Voltage Control Costs Fault Parameters Owners, Area, etc Custom Stability

Generator Impedances

Neutral Grounded

Internal Sequence Impedances

Positive	R : 0.00000	X : 0.02250
Negative	R : 0.00000	X : 0.02250
Zero	R : 0.00000	X : 0.00001

Generator Step Transformer

R:	0.00000
X:	0.00000
Tap:	1.00000

Neutral-to-Ground Impedance

R :	0.00000
X :	0.00000

Appendix 4 - Generator 2 Power and Voltage Controls Set Parameters (Rigth Generator)

Generator Options

Bus Number	3	<input type="button" value="Find By Number"/>	Status	<input type="radio"/> Open	Generator MVA Base
Bus Name	Bus 3	<input type="button" value="Find By Name"/>	<input checked="" type="radio"/> Closed	100.00	
ID	1	<input type="button" value="Find ..."/>			
Area Name	1	Fuel Type	UN (Unknown) [PW=0] [EPC=0]		
Labels ...	no labels	Unit Type			

Display Information Power and Voltage Control Costs Fault Parameters Owners, Area, etc Custom Stability

Power Control

MW Setpoint	0.000	MW Output	0.000	Part. Factor	10.00
Min. MW Output	0.000	<input type="checkbox"/> Available for AGC			
Max. MW Output	1000.000	<input checked="" type="checkbox"/> Enforce MW Limits during automatic control			

Voltage Control

Mvar Output	0.000	<input checked="" type="checkbox"/> Available for AVR	Regulated Bus Number	3																								
Min Mvars	-9900.000	<input type="checkbox"/> Use Capability Curve	SetPoint Voltage	1.050000																								
Max Mvars	9900.000	SetPoint Voltage Tol 0.000000																										
Mvar Capability Curve		Remote RegFactor 100.0																										
<table border="1"> <thead> <tr> <th></th> <th>MW</th> <th>Min Mvar</th> <th>Max Mvar</th> </tr> </thead> <tbody> <tr><td>1</td><td></td><td></td><td></td></tr> <tr><td>2</td><td></td><td></td><td></td></tr> <tr><td>3</td><td></td><td></td><td></td></tr> <tr><td>4</td><td></td><td></td><td></td></tr> <tr><td>5</td><td></td><td></td><td></td></tr> </tbody> </table>			MW	Min Mvar	Max Mvar	1				2				3				4				5				Line Drop Compensation Use LDC <input type="checkbox"/> No Xcomp 0.000100 Rcomp 0.000000		
	MW	Min Mvar	Max Mvar																									
1																												
2																												
3																												
4																												
5																												
Wind Control Mode		Voltage Droop Control																										
Mode	None	Name	<input type="button" value="Find..."/> <input type="button" value="Clear"/> <input type="button" value="Add..."/>																									
Power Factor	1.0000																											

OK Save Save to Aux Cancel Help

Generator #1 Parameters:

Appendix 5 -Generator 1 Display Info Set Parameters (Left Generator)

Generator Options

Bus Number	1	Find By Number	Status	<input type="radio"/> Open	Generator MVA Base
Bus Name	Bus 1	Find By Name	<input checked="" type="radio"/> Closed	100.00	
ID	1	Find ...			
Area Name	1	Fuel Type	UN (Unknown) [PW=0] [EPC=0]		
Labels ...	no labels	Unit Type			

Display Information Power and Voltage Control Costs Fault Parameters Owners, Area, etc Custom Stability

Display Size	10.0	Orientation	<input type="radio"/> Right	Rotor Shape	Dog Bone
<input checked="" type="checkbox"/> Scale Width with Size		<input type="radio"/> Up	<input checked="" type="radio"/> Left	<input type="checkbox"/> Fill Rotor Symbol with Color 2	
Display Width	6.67	<input type="radio"/> Down		Fill with Color 2	
Pixel Thickness	1				
<input checked="" type="checkbox"/> Anchored					
Link To New Generator					

Appendix 6 -Generator 1 Fault Parameters Set Parameters (Left Generator)

Generator Options

Bus Number	1	Find By Number	Status	<input type="radio"/> Open	Generator MVA Base
Bus Name	Bus 1	Find By Name	<input checked="" type="radio"/> Closed	100.00	
ID	1	Find ...			
Area Name	1	Fuel Type	UN (Unknown) [PW=0] [EPC=0]		
Labels ...	no labels	Unit Type			

Display Information Power and Voltage Control Costs Fault Parameters Owners, Area, etc Custom Stability

Generator Impedances

<input checked="" type="checkbox"/> Neutral Grounded	Generator Step Transformer		
	R:	0.00000	
	X:	0.00000	
	Tap:	1.00000	

Internal Sequence Impedances

Positive	R : 0.00000	X : 0.04500
Negative	0.00000	0.04500
Zero	0.00000	0.00001

Neutral-to-Ground Impedance

R :	0.00000
X :	0.00000

Appendix 7 -Generator 1 Power and Voltage Control Set Parameters (Left Generator)

Generator Options

Bus Number	1	Find By Number	Status	<input type="radio"/> Open	Generator MVA Base
Bus Name	Bus 1	Find By Name	<input checked="" type="radio"/> Closed	100.00	
ID	1	Find ...			
Area Name	1	Fuel Type	UN (Unknown) [PW=0] [EPC=0]		
Labels ...	no labels	Unit Type			

Display Information Power and Voltage Control Costs Fault Parameters Owners, Area, etc Custom Stability

Power Control

MW Setpoint	0.000	MW Output	0.000	Part. Factor	10.00
Min. MW Output	0.000	<input checked="" type="checkbox"/> Available for AGC			
Max. MW Output	1000.000	<input checked="" type="checkbox"/> Enforce MW Limits during automatic control			

Voltage Control

Mvar Output	0.000	<input checked="" type="checkbox"/> Available for AVR	Regulated Bus Number	1																									
Min Mvars	-9900.000																												
Max Mvars	9900.000	<input type="checkbox"/> Use Capability Curve	SetPoint Voltage	1.050000																									
Mvar Capability Curve																													
<table border="1"> <thead> <tr> <th></th> <th>MW</th> <th>Min Mvar</th> <th>Max Mvar</th> </tr> </thead> <tbody> <tr><td>1</td><td></td><td></td><td></td></tr> <tr><td>2</td><td></td><td></td><td></td></tr> <tr><td>3</td><td></td><td></td><td></td></tr> <tr><td>4</td><td></td><td></td><td></td></tr> <tr><td>5</td><td></td><td></td><td></td></tr> </tbody> </table>			MW	Min Mvar	Max Mvar	1				2				3				4				5				SetPoint Voltage Tol 0.000000 Remote RegFactor 100.0 Line Drop Compensation Use LDC No Xcomp 0.000100 Rcomp 0.000000			
	MW	Min Mvar	Max Mvar																										
1																													
2																													
3																													
4																													
5																													
Wind Control Mode		Voltage Droop Control																											
Mode	None	Name																											
Power Factor	1.0000	Find...	Clear	Add...																									

OK

Save

Save to Aux

Cancel

Help

Bus Parameters:

Appendix 8 - Bus 1 Parameter

Bus Options X

Bus Number	1	<input type="button" value="Find By Number"/> <input type="button" value="Find ..."/>	
Bus Name	Bus 1	<input type="button" value="Find By Name"/>	
Nominal Voltage	15.0000 kV		
Labels ...	no labels		
	Number	Name	
Area	<input type="button" value="Change"/>	1	<input type="button" value="View Area Dialog"/>
Balancing Authority	<input type="button" value="Change"/>	1	<input type="button" value="View Zone Dialog"/>
Zone	<input type="button" value="Change"/>	1	<input type="button" value="View Owner Dialog"/>
Owner	<input type="button" value="Change"/>	1	<input type="button" value="View Substation Dialog"/>
Substation	<input type="button" value="Change"/>		
Data Maintainer	<input type="button" value="Change"/>		

Bus Information

Bus Voltage
Voltage (p.u.) 1.0500

Angle (degrees) 0

System Slack Bus

Appendix 9 - Bus 2 Parameter

Bus Options

Bus Number	2	<input type="button" value="Find By Number"/>	<input type="button" value="Find ..."/>
Bus Name	Bus 2	<input type="button" value="Find By Name"/>	
Nominal Voltage	345.0000 kV		
Labels ...	no labels		
	Number	Name	
Area	<input type="button" value="Change"/> 1	<input type="button" value="View Area Dialog"/>	
Balancing Authority	<input type="button" value="Change"/> 1	<input type="button" value="View Zone Dialog"/>	
Zone	<input type="button" value="Change"/> 1	<input type="button" value="View Owner Dialog"/>	
Owner	<input type="button" value="Change"/> 1	<input type="button" value="View Substation Dialog"/>	
Substation	<input type="button" value="Change"/>		
Data Maintainer	<input type="button" value="Change"/>		

Bus Information

Bus Voltage

Voltage (p.u.)	1.05	<input type="button" value="Bus Voltage Regulator Devices"/>
Angle (degrees)	0	

System Slack Bus

Appendix 10 - Bus 3 Parameter

Bus Options

Bus Number	3	Find By Number	Find ...
Bus Name	Bus 3	Find By Name	
Nominal Voltage	15.0000 kv		
Labels ...	no labels		
	Number	Name	
Area	Change	1	View Area Dialog
Balancing Authority	Change	1	View Zone Dialog
Zone	Change	1	View Owner Dialog
Owner	Change	1	View Substation Dialog
Substation	Change		
Data Maintainer	Change		

Bus Information Display Attached Devices Geography Custom Stability

Bus Voltage

Voltage (p.u.)	1.0500	Bus Voltage Regulator Devices
Angle (degrees)	0.000	

System Slack Bus

OK Save Save to Aux Cancel

Appendix 11 - Bus 4 Parameter

Bus Options

Bus Number	4	Find By Number	Find ...
Bus Name	Bus 4	Find By Name	
Nominal Voltage	345.0000 kV		
Labels ...	no labels		
	Number	Name	
Area	Change	1	View Area Dialog
Balancing Authority	Change	1	View Zone Dialog
Zone	Change	1	View Owner Dialog
Owner	Change	1	View Substation Dialog
Substation	Change		
Data Maintainer	Change		

Bus Information Display Attached Devices Geography Custom Stability

Bus Voltage

Voltage (p.u.)	1.05	Bus Voltage Regulator Devices
Angle (degrees)	0	

System Slack Bus

OK Save Save to Aux Cancel

Appendix 12 - Bus 5 Parameter

Bus Options

Bus Number	5	Find By Number	Find ...
Bus Name	Bus 5	Find By Name	
Nominal Voltage	345.0000	kV	
Labels ...	no labels		
	Number	Name	
Area	Change	1	View Area Dialog
Balancing Authority	Change	1	View Zone Dialog
Zone	Change	1	View Owner Dialog
Owner	Change	1	View Substation Dialog
Substation	Change		
Data Maintainer	Change		

Bus Information Display Attached Devices Geography Custom Stability

Bus Voltage

Voltage (p.u.)	1.0500	Bus Voltage Regulator Devices
Angle (degrees)	0.000	

System Slack Bus

OK Save Save to Aux Cancel

Transformer #1 Parameters:

Appendix 13 - Transmission #1 Parameters set Parameters

Branch Options

Transformer	From Bus	To Bus	Circuit	<input type="button" value="Find By Numbers"/> <input type="button" value="Find By Names"/> <input type="button" value="Find ..."/>
Number	1	5	1	<input checked="" type="checkbox"/> From End Metered
Name	Bus 1	Bus 5		<input type="checkbox"/> Default Owner (Same as From Bus)
Area Name	1 (1)	1 (1)		
Nominal kV	15.00	345.0		
Labels ...	no labels			

Display Parameters Transformer Control Fault Info Owner, Area, Zone, Sub Custom Stability Geography

Status <input type="radio"/> Open <input checked="" type="radio"/> Closed	Per Unit Impedance Parameters Series Resistance (R) 0.000000 Series Reactance (X) 0.020000	MVA Limits Limit A 1200.000 Limit B 1200.000 Limit C 1200.000 Limit D 0.000 Limit E 0.000 Limit F 0.000 Limit G 0.000 Limit H 0.000 Limit I 0.000 Limit J 0.000 Limit K 0.000
Branch Device Type Transformer	Shunt Charging (B) 0.000000 Shunt Conductance (G) 0.000000 Magnetizing Conductance 0.000000 Magnetizing Susceptance 0.000000	
<input type="checkbox"/> Allow Consolidation Length 0.00	Note: All Impedances above are in per unit on the system MVA and Voltage bases. Click following button to edit on Transformer Bases. <input type="button" value="Specify Transformer Bases and Impedances..."/>	
Normal Status <input type="radio"/> Open <input checked="" type="radio"/> Closed	<input type="checkbox"/> Has Line Shunts	<input type="button" value="Line Shunts"/>
<input type="button" value="Calculate Impedances >"/>		
<input type="button" value="Convert Transformer to Line"/> <input type="button" value="Exchange From and To Buses"/>		
<input type="checkbox"/> D-FACTS Devices on the Line		<input type="checkbox"/> Has D-FACTS

OK Save Save to Aux Cancel Help

Appendix 14 - Transmission #1 Fault info Set Parameters

Branch Options

Transformer	From Bus	To Bus	Circuit
Number	1	5	1
Name	Bus 1	Bus 5	
Area Name	1 (1)	1 (1)	
Nominal kV	15.00	345.0	

Find By Numbers
 Find By Names
 Find ...
 From End Metered
 Default Owner (Same as From Bus)

Labels ... no labels

[Display](#) [Parameters](#) [Transformer Control](#) [Fault Info](#) [Owner, Area, Zone, Sub](#) [Custom](#) [Stability](#) [Geography](#)

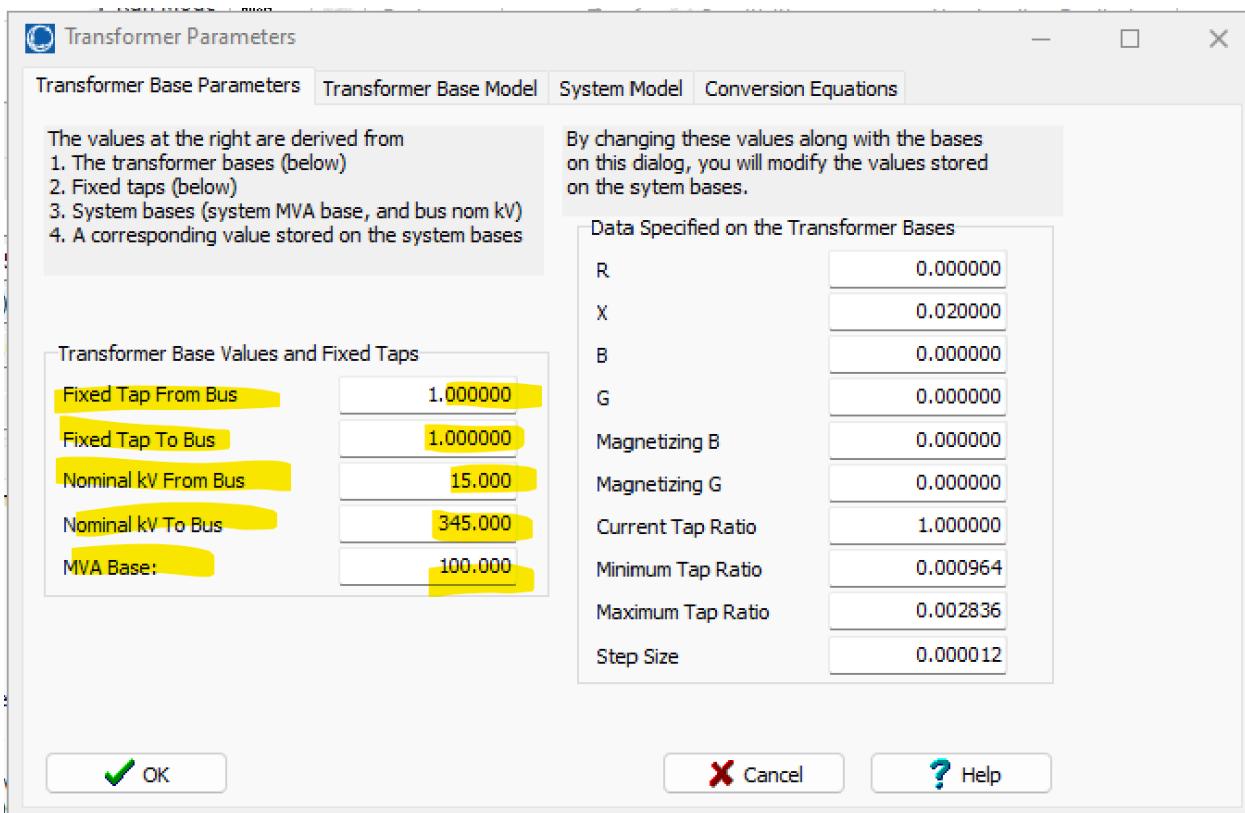
Treat as open circuit in zero sequence

Zero Sequence Impedance	Zero Sequence Line Shunt Admittance	Ground Impedance	
R : 0.000000	From G: 0.000000	R : 0.000000	
X : 0.020000	From B: 0.000000	X : 0.000000	
C : 0.000000	To G: 0.000000	R2 : 0.000000	
Secondary Zero Sequence Imp.	To B: 0.000000	X2 : 0.000000	
R2 : 0.000000	Neutral Impedance	R and X are values on the From side R2 and X2 are values on the To side	
X2 : 0.000000	Neutral R : 0.000000		
	Neutral X : 0.000000		

Configuration **Delta-Grounded Wye**

Note: Configuration only determines the grounding of the transformer windings.
Phase shifters must be entered as part of the Transformer Control data.

Appendix 15 - Transmission #1 Specify Transformer Based and Impedances



Transformer #2 Parameters:

Appendix 16 - Transmission #2 Parameters set Parameters

Branch Options

Transformer	From Bus	To Bus	Circuit
Number	3	4	1
Name	Bus 3	Bus 4	
Area Name	1 (1)	1 (1)	
Nominal kW	15.00	345.0	
<input checked="" type="checkbox"/> From End Metered			
<input checked="" type="checkbox"/> Default Owner (Same as From Bus)			
Labels ...		no labels	

Display **Parameters** **Transformer Control** **Fault Info** **Owner, Area, Zone, Sub** **Custom** **Stability** **Geography**

Status <input type="radio"/> Open <input checked="" type="radio"/> Closed	Per Unit Impedance Parameters Series Resistance (R) 0.000000 Series Reactance (X) 0.010000 Shunt Charging (B) 0.000000 Shunt Conductance (G) 0.000000 Magnetizing Conductance 0.000000 Magnetizing Susceptance 0.000000	MVA Limits Limit A 1200.000 Limit B 1200.000 Limit C 1200.000 Limit D 0.000 Limit E 0.000 Limit F 0.000 Limit G 0.000 Limit H 0.000 Limit I 0.000 Limit J 0.000 Limit K 0.000
Branch Device Type Transformer	Note: All Impedances above are in per unit on the system MVA and Voltage bases. Click following button to edit on Transformer Bases.	
<input type="checkbox"/> Allow Consolidation	<input type="button" value="Specify Transformer Bases and Impedances..."/>	
Length 0.00	<input type="button" value="Calculate Impedances >"/>	
Normal Status <input type="radio"/> Open <input checked="" type="radio"/> Closed	<input type="checkbox"/> Has Line Shunts <input type="button" value="Line Shunts"/>	
<input type="button" value="Convert Transformer to Line"/>		<input type="button" value="Exchange From and To Buses"/>
<input type="button" value="D-FACTS Devices on the Line"/>		<input type="checkbox"/> Has D-FACTS
<input type="button" value="OK"/>		<input type="button" value="Save"/>
<input type="button" value="Save to Aux"/>		<input type="button" value="Cancel"/>
		<input type="button" value="Help"/>

Appendix 17 - Transmission #2 Fault info Set Parameters

Branch Options

Transformer	From Bus	To Bus	Circuit	
Number Name Area Name Nominal kV	3 Bus 3 1 (1) 15.00	4 Bus 4 1 (1) 345.0	1	<input type="checkbox"/> Find By Numbers <input type="checkbox"/> Find By Names <input type="checkbox"/> Find ... <input checked="" type="checkbox"/> From End Metered <input checked="" type="checkbox"/> Default Owner (Same as From Bus)
Labels ...		no labels		

Display Parameters Transformer Control **Fault Info** Owner, Area, Zone, Sub Custom Stability Geography

Treat as open circuit in zero sequence

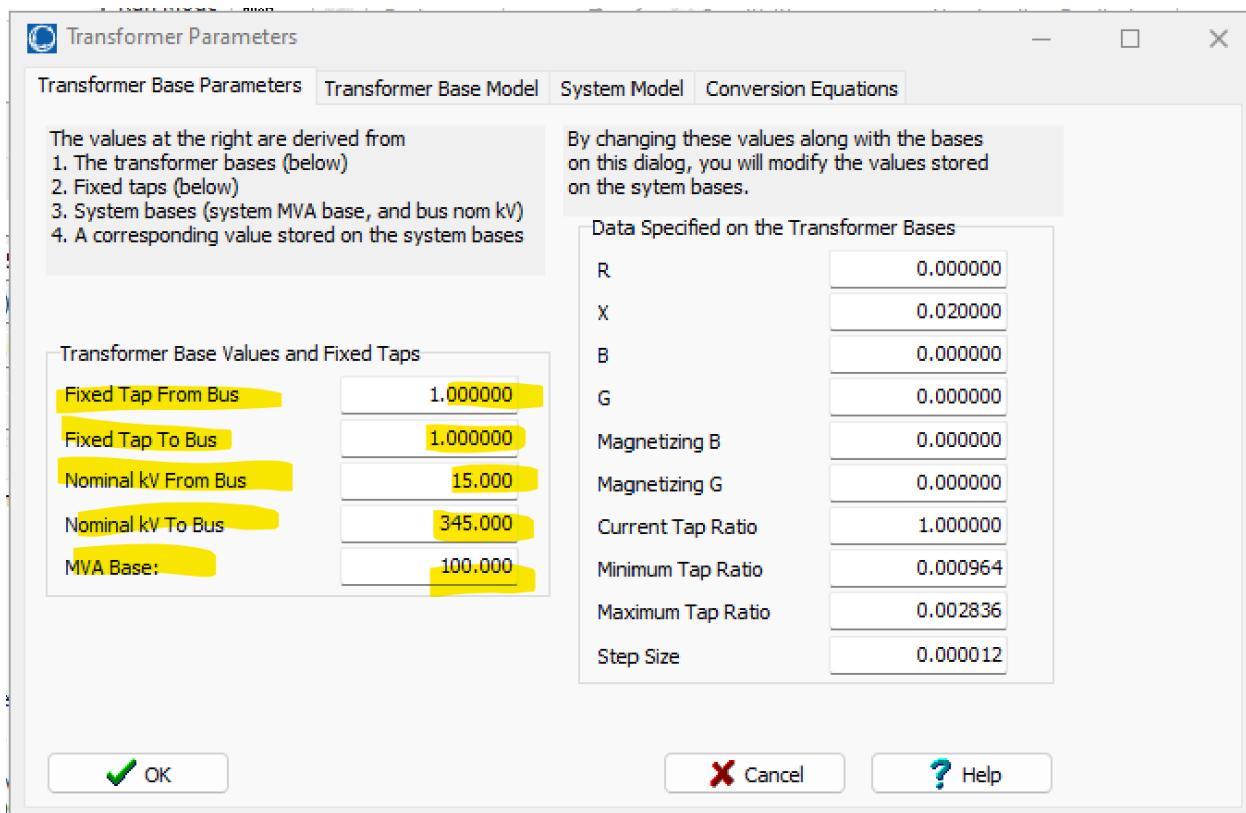
Zero Sequence Impedance	Zero Sequence Line Shunt Admittance	Ground Impedance
R : 0.000000 X : 0.010000 C : 0.000000	From G: 0.000000 From B: 0.000000 To G: 0.000000 To B: 0.000000	R : 0.000000 X : 0.000000 R2 : 0.000000 X2 : 0.000000
Secondary Zero Sequence Imp.	Neutral Impedance	R and X are values on the From side R2 and X2 are values on the To side
R2 : 0.000000 X2 : 0.000000	Neutral R : 0.000000 Neutral X : 0.000000	

Configuration: **Delta-Grounded Wye**

Note: Configuration only determines the grounding of the transformer windings.
Phase shifters must be entered as part of the Transformer Control data.

OK Save Save to Aux Cancel Help

Appendix 18 - Transmission #2 Specify Transformer Based and Impedances



Line #3 Parameters:

Appendix 19 - Line 3 Set Parameters

Branch Options

Line Number	From Bus 5	To Bus 4	Circuit 1	<input type="button" value="Find By Numbers"/> <input type="button" value="Find By Names"/>
Name Bus 5	Bus 4			<input type="button" value="Find ..."/>
Area Name 1 (1)	1 (1)			<input checked="" type="checkbox"/> From End Metered
Nominal kv 345.0	345.0			<input type="checkbox"/> Default Owner (Same as From Bus)
Labels ... Line3				

Display Parameters Fault Info Owner, Area, Zone, Sub Custom Stability Geography

Status <input type="radio"/> Open <input checked="" type="radio"/> Closed	Per Unit Impedance Parameters Series Resistance (R) 0.000000 Series Reactance (X) 0.025000 Shunt Charging (B) 0.000000 Shunt Conductance (G) 0.000000 <input type="checkbox"/> Has Line Shunts Line Shunts	MVA Limits Limit A 1200.000 Limit B 1200.000 Limit C 1200.000 Limit D 0.000 Limit E 0.000 Limit F 0.000 Limit G 0.000 Limit H 0.000 Limit I 0.000 Limit J 0.000 Limit K 0.000	
Branch Device Type Line <input type="button" value="▼"/> <input type="checkbox"/> Allow Consolidation Length 50.00 <input type="button" value="▲"/> <input type="button" value="Calculate Impedances >"/>			
Normal Status <input type="radio"/> Open <input checked="" type="radio"/> Closed			
<input type="button" value="Convert Line to Transformer"/> <input type="button" value="Exchange From and To Buses"/>		<input type="checkbox"/> Has D-FACTS	
<input type="button" value="OK"/> <input type="button" value="Save"/> <input type="button" value="Save to Aux"/> <input type="button" value="Cancel"/> <input type="button" value="Help"/>			

Line #2 Parameters:

Appendix 20 - Line 2 Set Parameters

Branch Options

Line Number	From Bus	To Bus	Circuit
5	2	1	
Name	Bus 5	Bus 2	
Area Name	1 (1)	1 (1)	
Nominal kV	345.0	345.0	
<input checked="" type="checkbox"/> From End Metered			
<input type="checkbox"/> Default Owner (Same as From Bus)			
Labels ... no labels			

Display Parameters Fault Info Owner, Area, Zone, Sub Custom Stability Geography

Status
 Open
 Closed

Branch Device Type
Line

Allow Consolidation

Length 100.00

Normal Status
 Open
 Closed

Per Unit Impedance Parameters

Series Resistance (R)	0.000000
Series Reactance (X)	0.050000
Shunt Charging (B)	0.000000
Shunt Conductance (G)	0.000000

Has Line Shunts

MVA Limits

Limit A	1200.000
Limit B	1200.000
Limit C	1200.000
Limit D	0.000
Limit E	0.000
Limit F	0.000
Limit G	0.000
Limit H	0.000
Limit I	0.000
Limit J	0.000
Limit K	0.000

D-FACTS Devices on the Line Has D-FACTS

OK Save Save to Aux Cancel Help

Line #1 Parameters:

Appendix 21 - Line 1 Set Parameters

Branch Options

Line Number	From Bus 2	To Bus 4	Circuit 1	<input type="button" value="Find By Numbers"/> <input type="button" value="Find By Names"/> <input type="button" value="Find ..."/>
Name	Bus 2	Bus 4		<input checked="" type="checkbox"/> From End Metered
Area Name	1 (1)	1 (1)		<input type="checkbox"/> Default Owner (Same as From Bus)
Nominal kV	345.0	345.0		
Labels ...		no labels		

Display Parameters Fault Info Owner, Area, Zone, Sub Custom Stability Geography

Status
 Open Closed

Branch Device Type
Line Allow Consolidation Length 200.00

Normal Status
 Open Closed

Per Unit Impedance Parameters
Series Resistance (R) 0.000000
Series Reactance (X) 0.100000
Shunt Charging (B) 0.000000
Shunt Conductance (G) 0.000000
 Has Line Shunts

MVA Limits

Limit A	1200.000
Limit B	1200.000
Limit C	1200.000
Limit D	0.000
Limit E	0.000
Limit F	0.000
Limit G	0.000
Limit H	0.000
Limit I	0.000
Limit J	0.000
Limit K	0.000

D-FACTS Devices on the Line Has D-FACTS

OK Save Save to Aux Cancel Help